

# Bottom Production Asymmetries at the LHC\*

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Sizeable leading particle asymmetries between *e.g.*  $D^-$  and  $D^+$  have been observed. It is of interest to investigate to what extent these phenomena translate to bottom production and higher energies. No previous experiment has observed asymmetries for bottom hadrons due to limited statistics or other experimental obstacles. Bottom asymmetries are in general expected to be smaller than for charm because of the larger bottom mass, but there is no reason why they should be absent. In the fixed target experiment HERA-B, bottom asymmetries could very well be large even at central rapidities, but the conclusion of the present study is that asymmetries at the LHC are likely to be small. In the following we study possible asymmetries between  $B$  and  $\bar{B}$  hadrons at the LHC within the Lund string fragmentation model [1] and the intrinsic heavy quark model [2].

In the string fragmentation model the perturbatively produced heavy quarks are colour connected to the beam remnants. This gives rise to beam-drag effects where the heavy hadron can be produced at larger rapidities than the heavy quark. The extreme case in this direction is the collapse of a small string, containing a heavy quark and a light beam remnant valence quark of the proton, into a single hadron. This gives rise to flavour correlations which are observed as asymmetries. Thus, in the string model, there can be coalescence between a perturbatively produced bottom quark and a light quark in the beam remnant producing a leading bottom hadron.

There is also the possibility to have coalescence between the light valence quarks and bottom quarks already present in the proton, because the wavefunction of the proton can fluctuate into Fock configurations containing a  $b\bar{b}$  pair, such as  $|uudb\bar{b}\rangle$ . In these states, two or more gluons are attached to the bottom quarks,

reducing the amplitude by  $\mathcal{O}(\alpha_s^2)$  relative to parton fusion. The longest-lived fluctuations in states with invariant mass  $M$  have a lifetime of  $\mathcal{O}(2P_{\text{lab}}/M^2)$  in the target rest frame, where  $P_{\text{lab}}$  is the projectile momenta. Since the comoving bottom and valence quarks have the same rapidity in these states, the heavy quarks carry a large fraction of the projectile momentum and can thus readily combine to produce bottom hadrons with large longitudinal momenta. Such a mechanism can then dominate the hadroproduction rate at large  $x_F$ . This is the underlying assumption of the intrinsic heavy quark model [2], in which the wave function fluctuations are initially far off shell. However, they materialize as heavy hadrons when light spectator quarks in the projectile Fock state interact with the target.

We have studied possible production asymmetries between  $b$  and  $\bar{b}$  hadrons, especially  $B^0$  and  $\bar{B}^0$ , as predicted by the Lund string fragmentation model and the intrinsic heavy quark model. We find negligible asymmetries for central rapidities and large  $p_T$  (in general, less than 1%). For some especially favoured kinematical ranges such as  $y > 3$  and  $5 < p_T < 10$  GeV the collapse asymmetry could be as high as 1–2%. Intrinsic bottom becomes important only for  $x_F > 0.25$  and  $p_T < 5$  GeV, corresponding to  $y > 6.5$ .

[1] E. Norrbin and T. Sjöstrand, Phys. Lett. **B442** (1998) 407.

[2] S.J. Brodsky, P. Hoyer, C. Peterson and N. Sakai, Phys. Lett. **B93** (1980) 451; S.J. Brodsky, C. Peterson and N. Sakai, Phys. Rev. **D23** (1981) 2745.

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